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Oishi et al.

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(54) **VEHICLE CONTROL APPARATUS**

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See application file for complete search history.

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ABSTRACT

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B60W 10/06 (2006.01)

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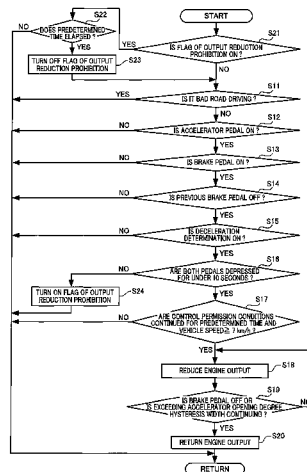
(52) **U.S. Cl.**
CPC **B60W 10/06** (2013.01); **B60T 7/042** (2013.01); **B60T 17/221** (2013.01);
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(58) **Field of Classification Search**

CPC F02D 2011/101; F02D 2011/00; F02D 2011/02; F02D 2011/102; F02D 2011/103

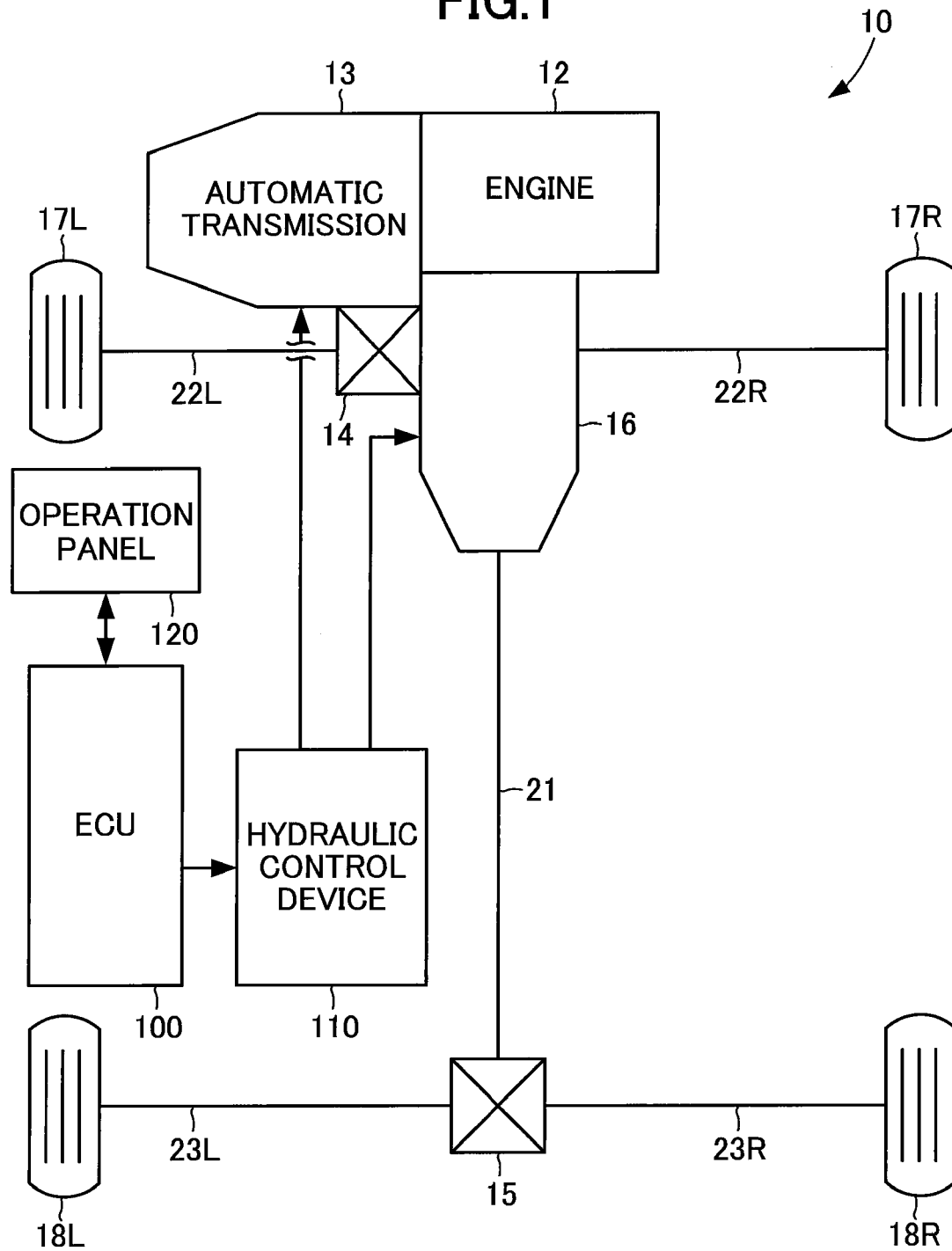
When an ECU determines that an accelerator is “ON” and a brake is “ON”, the ECU determines whether or not the brake previously depressed is “OFF”. When the ECU determines that the brake previously depressed is “OFF” and that the vehicle is in the reduced speed state, the vehicle control apparatus is configured to execute an engine output reduction control process under the condition that the simultaneous depressions of the accelerator and brake pedals continues for less than 10 seconds and the vehicle speed is not less than 7 km/hr. When the simultaneous depressions of the accelerator and brake pedals continues for no less than 10 seconds, the ECU is configured to make an output reduction prohibition flag “ON” and not to execute the engine output reduction control process until a predetermined time elapses.

12 Claims, 6 Drawing Sheets



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FIG. 1



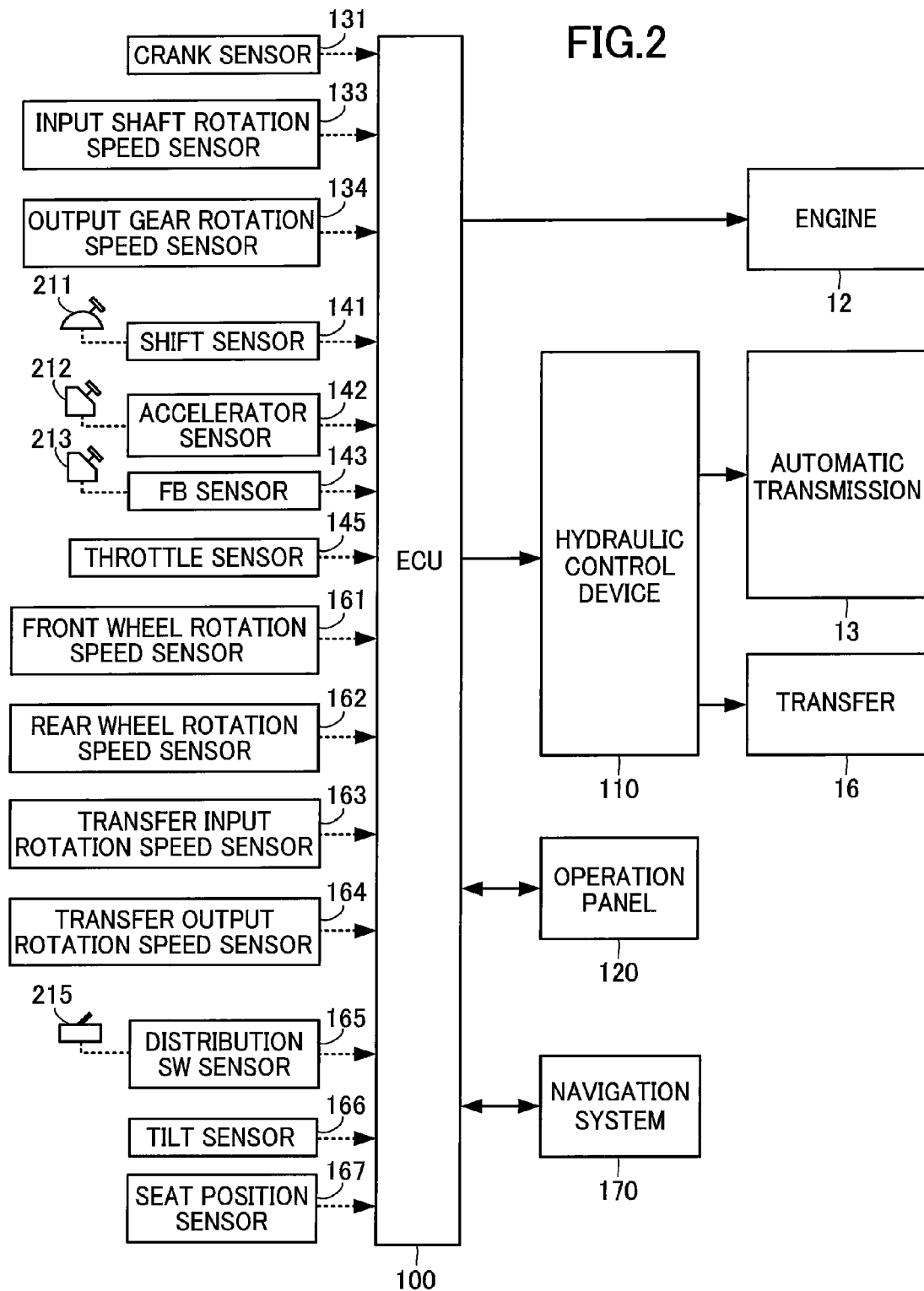


FIG.3

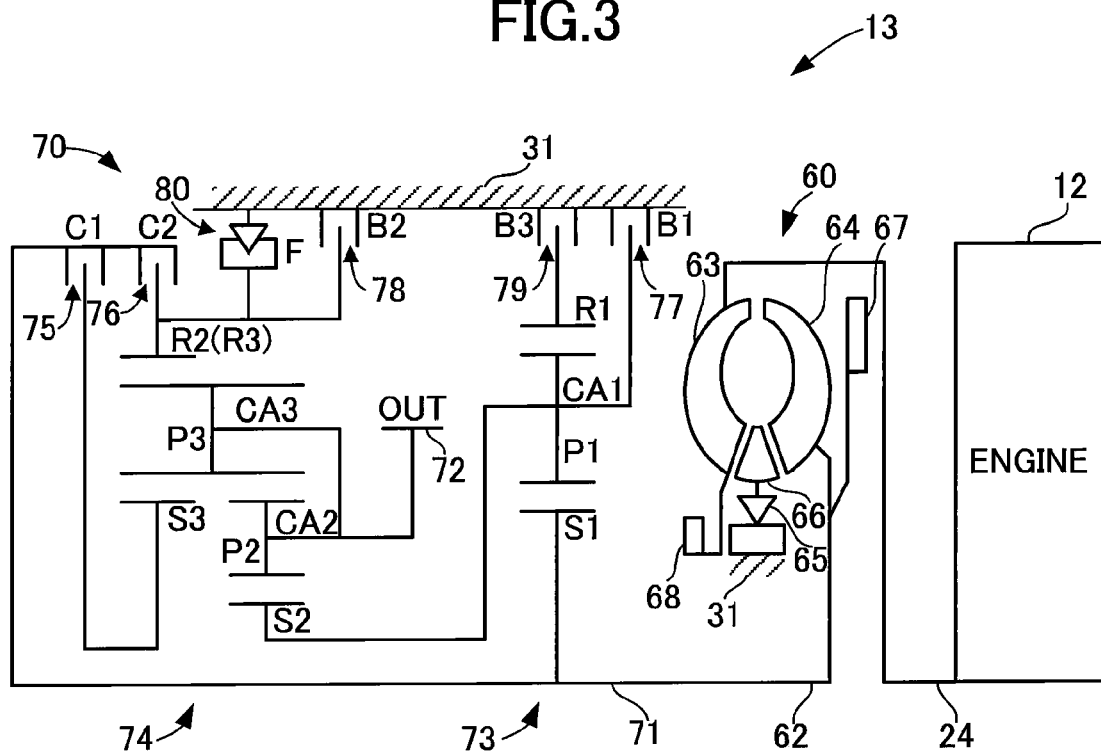


FIG. 4

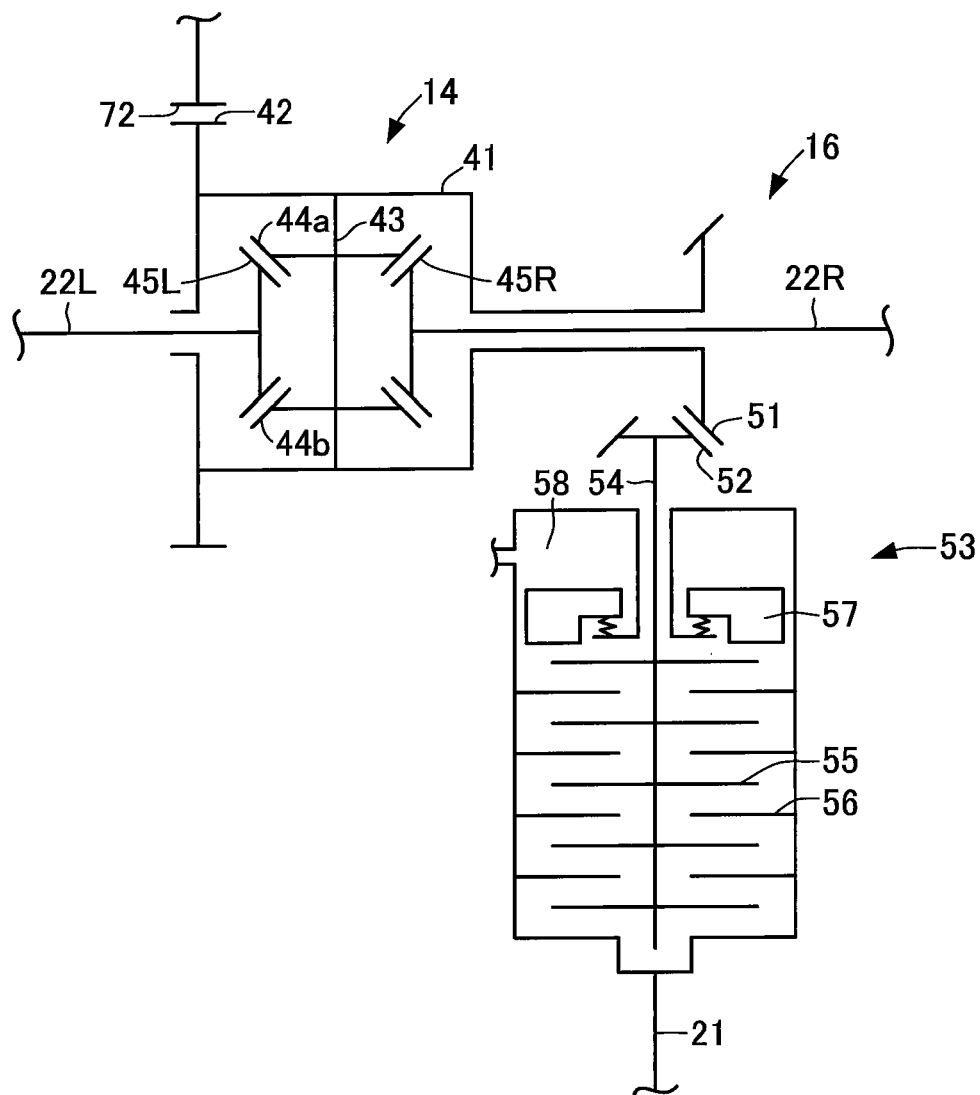
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	P	×	×	×	×	×	×
	R	×	×	×	○	○	×
	N	×	×	×	×	×	×
D	1st	○	×	×	⊙	×	△
	2nd	○	×	○	×	×	×
	3rd	○	×	×	×	○	×
	4th	○	○	×	×	×	×
	5th	×	○	×	×	○	×
	6th	×	○	○	×	×	×

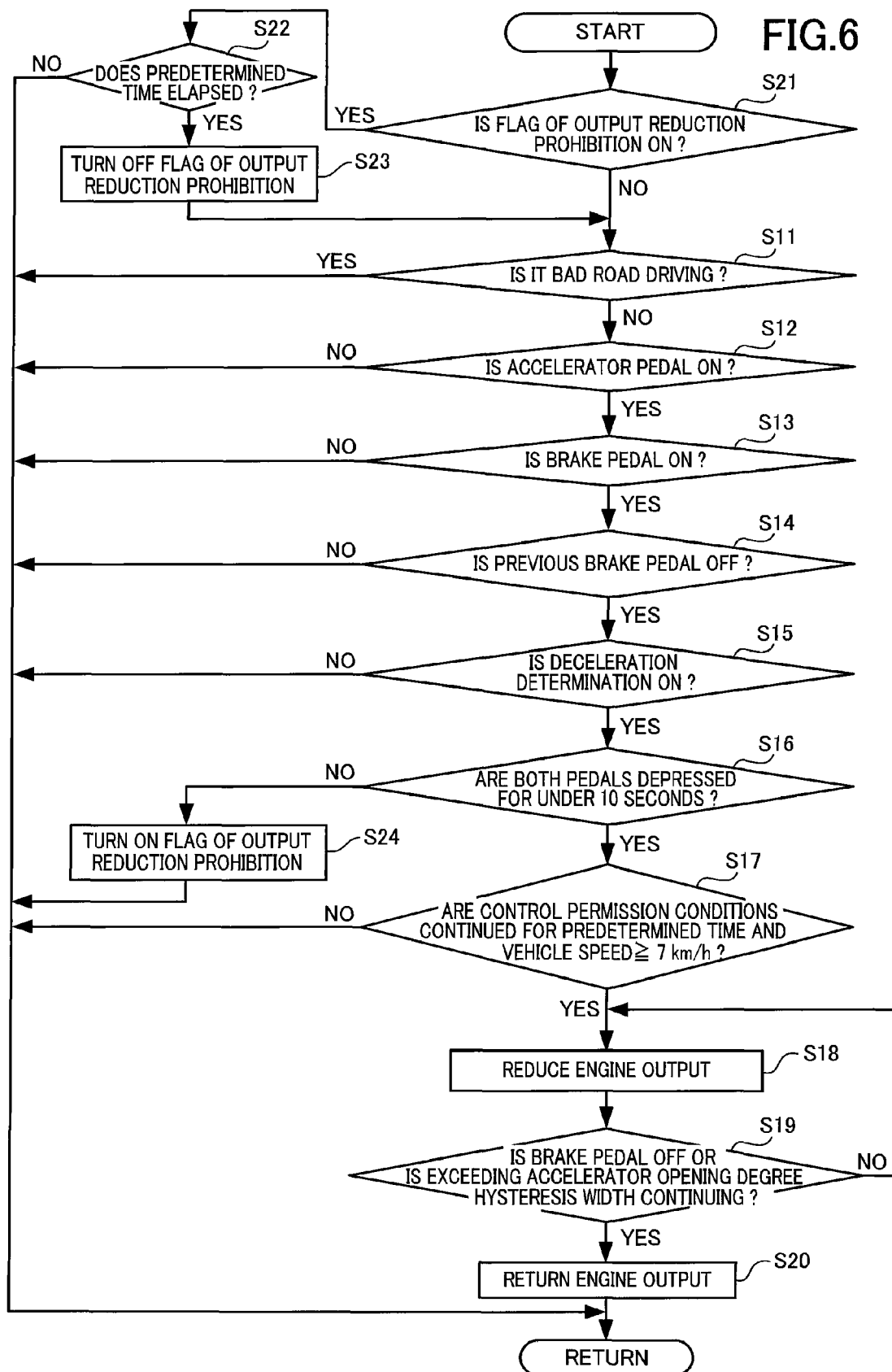
○ ENGAGED × DISENGAGED

⊙ ENGAGED ONLY WHEN ENGINE BRAKE IS APPLIED

△ ENGAGED ONLY WHEN DRIVING

FIG. 5





1

VEHICLE CONTROL APPARATUS

This is a 371 national phase application of PCT/JP2009/006956 filed 17 Dec. 2009, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a vehicle control apparatus, and more particularly to a vehicle control apparatus that controls the output of a power source.

BACKGROUND ART

In general, a vehicle has three fundamentally necessary abilities including a “driving force” as an ability of “advancing”, a “steering force” as an ability of “turning”, and a “braking force” as an ability of “stopping”.

The “driving force” is a power, i.e., a torque generated by a power source of an internal combustion engine (hereinafter simply referred to as “engine”) in response to such an amount of depression of an accelerator pedal and transmitted through a transmission to driving wheels to be obtained as a frictional reaction force of the driving wheels and a road surface allowing the driving wheels to travel thereon. The “steering force” is obtained by a steering device capable of changing the advancing direction of, for example, front wheels in response to the operation amount of a steering wheel. The “braking force” is generated in response to the amount of depression of a brake pedal by slowing down or stopping the rotation of the driving wheels to generate a frictional reaction force of the driving wheels and the road surface allowing the vehicle to be stopped.

In general, the accelerator pedal and the brake pedal are located adjacent to each other in the neighborhood of the location of the driver’s feet. Many drivers depress selectively the accelerator pedal or the brake pedal only with his or her right foot to control the “driving force” and the “braking force”, viz., to control a vehicle speed.

Therefore, there are some cases in which the simultaneous depressions of the accelerator pedal and the brake pedal as previously mentioned are apt to lead to deterioration in drivability.

There has so far been known a vehicle control apparatus which can reduce an engine torque in the event that the accelerator pedal and the brake pedal are depressed at the same time (see, for example, Patent Document 1).

The previously mentioned conventional vehicle is constructed to reduce the torque outputted by the engine with the fuel injection amount of the engine being temporarily reduced in the case that the accelerator pedal and the brake pedal are depressed at the same time.

CITATION LIST**Patent Literature**

{PTL1}

Patent Document 1: Japanese Patent Application Publication No. 62-051737

SUMMARY OF INVENTION**Technical Problems**

However, the conventional vehicle control apparatus is constructed to uniformly reduce the fuel injection amount to

2

the engine and thereby reduce the torque irrespective of the vehicle travelling state when the accelerator pedal and the brake pedal are depressed by the driver at the same time. This results in the fact that the conventional vehicle control apparatus reduces the torque of the engine regardless of the intention of the driver. Therefore, the conventional vehicle control apparatus causes a hesitation and other unfavorable phenomena on the vehicle when the depressions of both the accelerator pedal and the brake pedal are depressed intentionally by the driver, thereby leading to problems such as deteriorated drivability.

As there is no clutch pedal in a vehicle with an automatic transmission (hereinafter simply referred to as “AT car”), some drivers depress the brake pedal with the left foot and thus depress the brake pedal and the accelerator pedal with the left foot and the right foot, respectively. For such drivers using both their feet separately for the brake pedal and the accelerator pedal, even if the driver is just putting a foot on the brake pedal, the amount of the brake pedal depression may be large, and the state may be determined as brake-on by the conventional vehicle control apparatus. In such a case, if the engine output is reduced, hesitation on the vehicle is caused, thereby leading to problems such as deteriorated drivability.

The present invention has been made to solve such conventional problems as previously mentioned. It is therefore an object of the present invention to provide a vehicle control apparatus which can prevent the deterioration of the drivability.

Solution to Problem

In order to solve the above problems, a vehicle control apparatus according to the present invention, (1) a vehicle control apparatus for a vehicle provided with a power source, an accelerator pedal, and a brake pedal, the vehicle control apparatus comprising: an accelerator detection unit for detecting a depression of the accelerator pedal; a brake detection unit for detecting a depression of the brake pedal; a permission condition determination unit for determining that a control permission condition is established when the depression of the accelerator pedal is detected by the accelerator detection unit, and the depression of the brake pedal is detected by the brake detection unit; an output control unit for executing a reduction control to reduce a driving force outputted by the power source when the control permission condition established is determined by the permission condition determination unit; and an intention judgment determination unit for determining whether or not to judge that the accelerator pedal and the brake pedal are depressed intentionally by a driver in accordance with the results detected by the accelerator detection unit and the brake detection unit; the permission condition determination unit being operative to determine that the control permission condition is not established, and to prohibit the output control unit from executing the reduction control when the intention judgment determination unit determines not to judge whether or not the accelerator pedal and the brake pedal are depressed intentionally by the driver.

By the construction of the vehicle control apparatus as set forth in the above definition (1), when the control permission condition is established, the reduction control to reduce the driving force outputted from the power source is executed, and when the intention judgment determination unit determines not to judge whether or not the accelerator pedal and the brake pedal are depressed intentionally by the driver, the reduction control is not executed. As a consequence, when the possibility is high that the brake pedal is depressed unintentionally,

3

tionally by the driver, the vehicle can be prevented from being reduced the driving force outputted from the power source, thereby making it possible to prevent the drivability from being deteriorated.

In the vehicle control apparatus as set forth in the above definition (1), a vehicle control apparatus according to the present invention comprising: (2) the intention judgment determination unit is operative to determine not to judge whether or not the accelerator pedal and the brake pedal are depressed intentionally by the driver when the state that the depression of the accelerator pedal is detected by the accelerator detection unit, and the state that the depression of the brake pedal is detected by the brake detection unit continues for a predetermined time period.

By the construction of the vehicle control apparatus as set forth in the above definition (2), when the state that the depression of both the accelerator pedal and the brake pedal are concurrently detected continues for a predetermined time period, the driver may tend to depress the accelerator pedal and the brake pedal separately with both feet and may be just putting a foot on the brake pedal. In this case, the driver may not have intention to depress the brake pedal and the intention judgment determination unit determines not to judge whether or not the brake pedal are depressed intentionally by the driver. As a consequence, the vehicle control apparatus can prevent the reduction control from being executed excessively and prevent the driving force from being reduced unnecessarily, thereby making it possible to prevent the drivability from being deteriorated.

In the vehicle control apparatus as set forth in the above definition (1) or (2), a vehicle control apparatus according to the present invention comprising: (3) the intention judgment determination unit is operative to determine not to judge whether or not the accelerator pedal and the brake pedal are depressed intentionally by the driver when the state that the depression of the accelerator pedal is detected by the accelerator detection unit, and the state that the depression of the brake pedal is detected by the brake detection unit occurs at a predetermined frequency.

By the construction of the vehicle control apparatus as set forth in the above definition (3), when the state that the depression of both the accelerator pedal and the brake pedal are concurrently detected at a predetermined frequency, the driver may tend to depress the accelerator pedal and the brake pedal separately with both feet and may be just putting a foot on the brake pedal in the same manner as described above. In this case, the driver may not have intention to operate the brake pedal and the intention judgment determination unit determines not to judge whether or not the brake pedal are depressed intentionally by the driver. As a consequence, the vehicle control apparatus can prevent the reduction control from being executed excessively and prevent the driving force from being reduced unnecessarily, thereby making it possible to prevent the drivability from being deteriorated.

In the vehicle control apparatus as set forth in any one of the above definitions (2) to (3), a vehicle control apparatus according to the present invention comprising: (4) the permission condition determination unit is operative to determine that the control permission condition is not established for a predetermined time period, and to prohibit the output control unit from executing the reduction control when the intention judgment determination unit determines not to judge whether or not the accelerator pedal and the brake pedal are depressed intentionally by the driver.

By the construction of the vehicle control apparatus as set forth in the above definition (4), as the state that the intention judgment determination unit determines not to judge whether

4

or not the brake pedal are depressed intentionally by the driver continues for a while, the vehicle control apparatus thus determines the control permission condition is not established, and thus the vehicle control apparatus can prevent the driving force from being reduced unnecessarily, thereby making it possible to prevent the drivability from being deteriorated. For example, in the case that the driver depresses the brake pedal significantly by fatigue even if the driver who tends to depress the accelerator pedal and the brake pedal separately with both feet is just putting a foot on the brake pedal, as the state that the depression of both the accelerator pedal and the brake pedal are concurrently detected continues for a while, the vehicle control apparatus determines the control permission condition is not established during the period. In addition, in the case that the vehicle control apparatus determines the accelerator pedal and the brake pedal are depressed intentionally by the driver, there is a high possibility that the accelerator pedal and the brake pedal are depressed again intentionally at the same time. Therefore, the vehicle control apparatus can prevent the driving force from being reduced unnecessarily by determining the control permission condition is not established for the predetermined time period, thereby making it possible to prevent the drivability from being deteriorated.

In the vehicle control apparatus as set forth in any one of the above definitions (1) to (4), a vehicle control apparatus according to the present invention comprising: (5) the permission condition determination unit is operative to determine that the control permission condition is not established until the end of a current trip, and to prohibit the output control unit from executing the reduction control when the intention judgment determination unit determines not to judge whether or not the operations of the accelerator pedal and the brake pedal are depressed intentionally by the driver.

By the construction of the vehicle control apparatus as set forth in the above definition (5), in the case that the vehicle control apparatus determines not to judge the intention of the driver, as the control permission condition is not established until the end of the current trip, there is low possibility that the driver is changed until the end of the current trip in the case that the vehicle control apparatus determines not to judge the intention of the driver because of the driver's operation methods, habits and others. Therefore, the vehicle control apparatus can prevent the driving force from being reduced unnecessarily by determining the control permission condition is not established, thereby making it possible to prevent the drivability from being deteriorated. On the other hand, in the case that the vehicle control apparatus judges that the acceleration pedal and brake pedal is depressed intentionally by the driver, even if the acceleration pedal and brake pedal are depressed again simultaneously during the current trip, there is high possibility that the operation is executed intentionally by the driver. Therefore, the vehicle control apparatus can prevent the driving force from being reduced unnecessarily by determining the control permission condition is not established until the end of the current trip, thereby making it possible to prevent the drivability from being deteriorated. Here, the trip means, for example, the time period from the time a starting switch of a vehicle such as an ignition switch is turned on until the time the starting switch is turned off.

In the vehicle control apparatus as set forth in any one of the above definitions (1) to (5), a vehicle control apparatus according to the present invention comprising: (6) the permission condition determination unit is operative to determine that the control permission condition is established when the depression of the brake pedal is detected by the

5

brake detection unit in the state that the depression of the accelerator pedal is detected by the accelerator detection unit.

By the construction of the vehicle control apparatus as set forth in the above definition (6), the vehicle control apparatus thus constructed can reduce the driving force outputted from the power source when the brake pedal depressed with the accelerator pedal being depressed is detected, resulting from the driving condition under which the driver generally requests for braking of the vehicle in the event that the brake pedal is depressed with the accelerator pedal being depressed.

In the vehicle control apparatus as set forth in any one of the above definition (1) to (6), a vehicle control apparatus according to the present invention comprising: (7) a speed reduction determination unit for detecting the state of the vehicle to determine a speed reduction of the vehicle, and in which the permission condition determination unit is operative to determine that the control permission condition is established when the speed reduction of the vehicle is determined by the speed reduction determination unit.

By the construction of the vehicle control apparatus as set forth in the above definition (7), the vehicle control apparatus thus constructed can reduce the driving force outputted from the power source when determining the deceleration of vehicle under the condition of both the accelerator pedal and the brake pedal being depressed, resulting from the fact that the vehicle is under the state that the driver requests to brake when the vehicle is being decelerated.

In the vehicle control apparatus as set forth in the above definition (7), a vehicle control apparatus according to the present invention comprising: (8) a brake depression force detection unit for detecting a depression amount of the brake pedal, and in which the speed reduction determination unit is operative to determine the speed reduction in accordance with the depression amount of the brake pedal detected by the brake depression force detection unit.

By the construction of the vehicle control apparatus as set forth in the above definition (8), the vehicle control apparatus thus constructed can determine that the driver is requesting for braking of the vehicle in accordance with the depression amount of the brake pedal, resulting from the fact the depression amount of the brake pedal is increased as compared with the depression amount of the brake pedal depressed together with the accelerator pedal when the driver is requesting for braking the vehicle. As a consequence, the driving force outputted from the power source can be reduced when the deceleration of vehicle is determined in accordance with the depression amount of the brake pedal.

In the vehicle control apparatus as set forth in the above definition (7), a vehicle control apparatus according to the present invention comprising: (9) a vehicle body speed detection unit for detecting a travel speed of the vehicle from the rotation number of driven wheels, and in which the speed reduction determination unit is operative to determine the speed reduction in accordance with the varied rotation number of the driven wheels detected by the vehicle body speed detection unit.

By the construction of the vehicle control apparatus as set forth in the above definition (9), the vehicle control apparatus thus constructed can determine whether or not the vehicle is decelerated in accordance with the rotation speed of the rolling wheels, resulting from the fact that the rotation speed of the rolling wheels is decreased when the vehicle is being decelerated. The driving force outputted from the power source can be reduced when the reduction in the rotation speed of the rolling wheels is detected.

In the vehicle control apparatus as set forth in the above definition in any one of (1) to (9), a vehicle control apparatus

6

according to the present invention comprising: (10) a vehicle speed detection unit for detecting a vehicle speed, and in which the output control unit is operative to execute the reduction control when the vehicle speed detected by the vehicle speed detection unit is not less than a predetermined vehicle speed.

By the construction of the vehicle control apparatus as set forth in the above definition (10), the vehicle control apparatus thus constructed can execute the reduction control of driving force if the vehicle speed is at the predetermined vehicle speed or faster, and can allow the reduction control of driving force not to be executed so as to respond for a hill start and the like if the vehicle speed is below the predetermined vehicle speed. This makes it possible to prevent the deterioration of drivability while the necessary transmission of torque is performed.

In the vehicle control apparatus as set forth in the above definition in any one of (1) to (10), a vehicle control apparatus according to the present invention comprising: (11) the output control unit is operative to execute the reduction control when the control permission condition established for no less than a predetermined time is determined by the permission condition determination unit.

By the construction of the vehicle control apparatus as set forth in the above definition (11), the vehicle control apparatus thus constructed not only can prevent the reduction control from being excessively executed but can prevent the driving force from being unnecessarily decreased. As a result, the deterioration of drivability can be prevented.

In the vehicle control apparatus as set forth in any one of the above definition (1) to (11), a vehicle control apparatus according to the present invention comprising: (12) the accelerator detection unit is operative to detect an amount of depression of the accelerator pedal, and the output control unit is operative to finish the reduction control when the amount of depression of the accelerator pedal detected by the accelerator detection unit is varied larger than a predetermined depression amount.

By the construction of the vehicle control apparatus as set forth in the above definition (12), the vehicle control apparatus thus constructed can determine that there is a request to accelerate for the vehicle when the depression amount of the accelerator pedal is drastically changed. As consequence, the vehicle control apparatus can finish the reduction control, and can prevent the deterioration of drivability.

In the vehicle control apparatus as set forth in the above definition (11), a vehicle control apparatus according to the present invention comprising: (13) the output control unit is operative to finish the reduction control of the driving force outputted from the power source when the brake pedal not depressed is detected by the brake detection unit.

By the construction of the vehicle control apparatus as set forth in the above definition (13), the vehicle control apparatus thus constructed can prevent the reduction of the driving force from unnecessarily continuing, thereby making it possible to prevent the drivability from being deteriorated.

Advantageous Effects of Invention

The vehicle control apparatus according to the present invention can allow the driver to drive without reducing the driving force outputted from the power source when the possibility is high that the driver is depressing the brake pedal unintentionally, thereby making it possible to prevent the drivability from being deteriorated

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic block diagram of a vehicle equipped with a control apparatus according to an embodiment of the present invention.

FIG. 2 is a schematic block diagram of the vehicle control according to the embodiment of the present invention.

FIG. 3 is a schematic block diagram of an automatic transmission in the embodiment of the present invention.

FIG. 4 is a table showing the engagement state of frictional engagement elements to realize each shift stage in the embodiment of the present invention.

FIG. 5 is a schematic block diagram representing the constructions of a front differential mechanism and a transfer in the embodiment of the present invention.

FIG. 6 is a flowchart showing a vehicle control process in the embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

The embodiments of the invention will be described hereinafter with reference to the drawings.

First, the construction of a vehicle having a control apparatus according to the embodiment of the present invention will be described with reference to the schematic block diagram of the vehicle shown in FIG. 1 and the schematic block diagram of the vehicle control shown in FIG. 2.

As shown in FIG. 1, a vehicle 10 according to the present embodiment comprises an engine 12 serving as a power source, an automatic transmission 13 that transmits a torque generated by the engine 12 and forms transmission stages corresponding to the travel conditions of the vehicle 10, a front differential mechanism 14 that distributes the torque transmitted from the automatic transmission 13 to left and right front drive shafts 22L, 22R, a rear differential mechanism 15 that distributes the torque transmitted by a propeller shaft 21 to left and right rear drive shafts 23L, 23R, and a transfer 16 that distributes the torque transmitted by the automatic transmission 13 to front wheels 17L, 17R and rear wheels 18L, 18R.

Further, the vehicle 10 comprises an ECU (Electronic Control Unit) 100 serving as a vehicle electronic control unit that controls the entire vehicle 10, a hydraulic pressure control device 110 that hydraulically controls the automatic transmission 13 and the transfer 16, an operation panel 120 serving as an input/output interface with the driver, and a navigation system 170.

Further, the vehicle 10 is provided with a crank sensor 131, an input shaft rotation speed sensor 133, an output gear rotation speed sensor 134, a shift sensor 141, an accelerator sensor 142, a foot brake sensor 143 (hereinafter simply referred to as "FB sensor"), a throttle sensor 145, a front wheel rotation speed sensor 161, a rear wheel rotation speed sensor 162, a transfer input rotation speed sensor 163, a transfer output rotation speed sensor 164, a distribution SW sensor 165, a tilt sensor 166, a seat position sensor 167, and the various kinds of other sensors not shown in the drawings. The previously mentioned sensors are adapted to output their detection signals to the ECU 100.

The engine 12 is constituted by a known power device which can output torque by combusting in a combustion chamber of a cylinder not shown a mixture of hydrocarbon fuel such as gasoline or diesel and air. The engine 12 is operated to intermittently repeat the actions of taking in the air mixture into the combustion chamber of the cylinder, combusting the mixture in the cylinder, and discharging exhaust gas to the outside of the cylinder to reciprocate a

piston in the cylinder to enable a crank shaft drivably coupled to the piston to be rotated, thereby transmitting the torque to the automatic transmission 13. The fuel to be used for the engine 12 may be an alcohol fuel including an alcohol such as ethanol.

The automatic transmission 13 includes a plurality of planetary gear devices each provided with a plurality of friction engagement elements constituted by clutches and brakes and operative to be selectively engaged or disengaged, thereby forming a plurality of transmission stages in response to the combination of the engagement and disengagement of the clutches and the brakes. The clutches and the brakes are constructed to be switched selectively into their engaged states or their disengaged states by the hydraulic pressure control device 110.

By this construction, the automatic transmission 13 functions as a staged transmission to reduce or increase the torque or rotation of the crank shaft of the engine 12 inputted as a driving force at a predetermined speed change ratio γ to be outputted to the front differential mechanism 14 and the transfer 16. This means that the automatic transmission 13 constitutes a plurality of speed change stages operable in response to the vehicle travel states and thus can carry out a speed conversion in response to the speed change stages. The detailed explanation about the automatic transmission 13 will be described later. The automatic transmission 13 may be composed of a continuously variable transmission by continuously changing the transmission speed change ratio.

The front differential mechanism 14 is operative to allow the rotation speed to be different between the front wheels 17R and 17L when the vehicle is travelling through a curved road. The front differential mechanism 14 comprises a plurality of gears to distribute and output the torque inputted by the automatic transmission 13 to the front drive shafts 22L, 22R. The front differential mechanism 14 may be constructed to have the front drive shafts 22L, 22R rotated at the same rotation speed, and thus may be operated under a diff-locked state having no difference in rotation speed between the front wheels 17L, 17R. The detailed explanation about the front differential mechanism 14 will be described hereinafter.

The rear differential mechanism 15 is substantially the same in construction as the front differential mechanism 14, so that the explanation about the rear differential mechanism 15 will be omitted hereinafter.

The transfer 16, also known as an auxiliary transmission, serves to distribute and transmit to the front differential mechanism 14 and the rear differential mechanism 15 the torque transmitted by the automatic transmission 13. This means that the torque transmitted by the automatic transmission 13 can be distributed and transmitted by the transfer 16 to the front wheels 17L, 17R and the rear wheels 18L, 18R.

The vehicle 10 in the present embodiment is exemplified as a front-wheel driving vehicle at the time of a usual drive state in which the front wheels 17L, 17R serve as driving wheels, respectively, when a four-wheel drive state is not selected. The transfer 16 is operative in the usual drive state and the four-wheel drive state as described hereinafter. This means that the transfer 16 can be operated at the usual drive state to distribute and transmit the torque transmitted by the automatic transmission 13 only to the front differential mechanism 14 but not to the rear differential mechanism 15. Further, the transfer 16 can be operated at the four-wheel drive state to distribute and transmit the torque transmitted by the automatic transmission 13 to the front differential mechanism 14 and the rear differential mechanism 15. The detailed description about the transfer 16 will become apparent as the description proceeds.

The ECU 100 comprises a CPU (Central Processing Unit) as a central processing unit, a ROM (Read Only Memory) for storing therein fixed data, a RAM (Random Access Memory) for storing data therein temporarily, an EEPROM (Electrically Erasable and Programmable Read Only Memory) made of a rewritable non-volatile memory, and an I/O interface circuit, and is designed to carry out the overall control of the vehicle 10.

As will be stated below, the ECU 100 is connected to the crank sensor 131, the accelerator sensor 142, and the other sensors. The ECU 100 is adapted to receive detection signals outputted from these sensors to detect an engine speed Ne, an accelerator opening degree Acc, and others.

The ECU 100 has an internal clock capable of measuring time. Further, the ECU 100 is adapted to control the hydraulic pressure control device 110 which can control the hydraulic pressure for the parts of the automatic transmission 13 and the transfer 16. However, the characteristic functions of the ECU 100 will be described hereinafter.

In addition, the ROM of the ECU 100 is adapted to store therein an operating table to be used for realizing the transmission stages, and a program for performing the vehicle control as described hereinafter. Further, the ROM of the ECU 100 is adapted to store therein a throttle opening degree control map, a gear shifting diagram, a lock-up control map, and various other values of the vehicle 10 which will not be described in detail hereafter.

Furthermore, the ROM of the ECU 100 is adapted to store therein an accelerator pedal depression determination value Acc_tv, a brake pedal depression determination value Bf_tv, a speed reduction brake determination value BfDc_tv, and an output reducing accelerator opening degree Acn.

The accelerator pedal depression determination value Acc_tv is indicative of a determination value that determines whether the vehicle 10 is under an accelerator-on state or an accelerator-off state in response to the depression amount of an accelerator pedal 212. The brake pedal depression determination value Bf_tv is indicative of a determination value that determines whether the vehicle 10 is under a brake-on state or a brake-off state in response to the depression amount of the foot brake pedal 213.

The speed reduction brake determination value BfDc_tv is indicative of a determination value that determines whether or not the vehicle 10 is under the speed reduction state in response to the depression amount of the foot brake pedal 213. The output reducing accelerator opening degree Acn is indicative of an accelerator opening degree set for reducing the output of the engine 12 from the real accelerator opening degree Acc when the control permission control later explained is established.

The speed reduction brake determination value BfDc_tv and the output reducing accelerator opening degree Acn may be calculated in response to the travelling state of the vehicle 10.

The hydraulic pressure control device 110 comprises linear solenoid valves SLT, SLU, an on-off solenoid valve SL, and linear solenoid valves SL1 to SLS, each of which is constituted by an electromagnetic valve to be controlled by the ECU 100. The hydraulic pressure control device 110 is adapted to be controlled by the ECU 100 to operate the above solenoid valves, so that the hydraulic circuit is switched and hydraulically controlled to operate the whole parts of the automatic transmission 13. Therefore, the hydraulic pressure control device 110 is adapted to control the solenoid valves so that the solenoid valves can be switched to establish a desired speed change stage in the automatic transmission.

The operation panel 120 is operably connected with the ECU 100 to receive operational requests inputted by the driver, to perform operational assistances to the driver, and to display vehicle travel states and others. For example, when the driver inputs one of the travel modes using switches provided on the operation panel 120, the I/O interface of the ECU 100 is inputted with the signal indicative of the travel mode inputted by the driver.

The navigation system 170 comprises a map information storage unit for storing information including topographic maps, a current position acquisition section using GPS (Global Positioning System) to acquire the current position of the vehicle 10, and a display section to display information to the driver, thereby acquiring the topographical information of the current position of the vehicle 10. The navigation system 170 is adapted to guide the driver from the current position to the destination in a similar manner to the car navigation systems known in the art.

The crank sensor 131 is adapted to detect the rotation speed of a crank shaft 24 under the control of the ECU 100 and to output a detection signal indicative of the detected rotation speed to the ECU 100. The ECU 100 is adapted to acquire as an engine speed Ne the rotation speed of the crank shaft 24 indicated by the detection signal outputted by the crank sensor 131.

The input shaft rotation speed sensor 133 is adapted to detect the rotation speed of an input shaft 71 described below under the control of the ECU 100 and to output a detection signal indicative of the detected rotation speed to the ECU 100. The input shaft 71 is directly connected with a turbine shaft 62 of a torque converter 60 described later. The input shaft 71 has a rotation speed the same as the rotation speed of the turbine shaft 62, so that an input shaft rotation speed Nm detected by the input shaft rotation speed sensor 133 is represented as a turbine rotation speed Nt.

The output gear rotation speed sensor 134 is adapted to detect the rotation speed of an output gear 72 described later under the control of the ECU 100 and to output a detection signal indicative of the detected rotation speed to the ECU 100.

In addition, the ECU 100 is adapted to be capable of calculating a speed change ratio γ in accordance with a transmission mechanism input shaft rotation speed Nm detected by the input shaft rotation speed sensor 133 and a transmission mechanism output rotation speed Nc detected by the output gear rotation speed sensor 134. Here, the "speed change ratio γ " is acquired by dividing the actual rotation speed Nm of the input shaft 71 by the actual rotation speed Nc of the output gear 72.

The shift sensor 141 is adapted to detect any one of switched positions taken by the shift lever 211 among the switched positions taken by the shift lever 211 under the control of the ECU 100 and to output a detection signal indicative of the switched position taken by the shift lever 211 to the ECU 100.

Here, the shift lever 211 is constructed to take, from the rear side to the forward side of the vehicle 10, a D position indicative of a driving range (hereinafter simply referred to as "D range"), an N position indicative of a neutral range, an R position indicative of a reverse range, and a P position indicative of a parking range.

If the shift lever 211 is located in the D range, a transmission mechanism 70 can establish any one of the speed stages from among the first to sixth speed stages as described below. In this way, the ECU 100 can select any one of the speed

11

stages from among the first to sixth speed stages in accordance with the vehicle speed V and a throttle opening degree θ_{th} .

The accelerator sensor **142** is under the control of the ECU **100**, and adapted to detect the accelerator pedal depression amount (hereinafter simply referred to as a “stroke”) and to output a detection signal indicative of the detected stroke to the ECU **100** when the accelerator pedal **212** is depressed. In addition, the ECU **100** is adapted to calculate the accelerator opening degree Acc from the stroke of the accelerator pedal **212** indicated by the detection signal outputted from the accelerator sensor **142**.

Therefore, the accelerator sensor **142** is adapted to detect the depression of the accelerator pedal **212**, and the depression amount of accelerator pedal **212**. This means that the accelerator sensor **142** constitutes an accelerator opening degree detection unit as defined in the present invention.

The FB sensor **143** is under the control of the ECU **100**, and adapted to detect the foot brake pedal depression amount (hereinafter simply referred to as a “stroke”) and to output the detection signal indicative of the detected stroke to the ECU **100** when the foot brake pedal **213** is depressed. In addition, the ECU **100** is adapted to calculate the brake pedal depression force Bf from the stroke of the foot brake pedal **213** indicated by the detection signal outputted from the FB sensor **143**.

This means that the FB sensor **143** is adapted to detect the depression of the foot brake pedal **213**. In other words, the FB sensor **143** constitutes a brake detection unit as defined in the present invention. In addition, the FB sensor **143** is adapted to detect the depression amount of the foot brake pedal **213**. In other words, the FB sensor **143** constitutes a brake pedal depression force detection unit as defined in the present invention.

In addition, the brake pedal depression force Bf indicative of the stroke of the foot brake pedal **213** detected by the FB sensor **143** may be replaced by a predetermined threshold value, i.e., the brake pedal depression determination value Bf_{tv} for the stroke of the foot brake pedal **213**. In this case, the FB sensor **143** may output a foot brake pedal on-off signal based on whether or not the stroke of the foot brake pedal **213** is exceeding the previous predetermined threshold value.

In addition, the FB sensor **143** may be adapted to detect the hydraulic pressure fed to the brake units provided on the front wheels **17L**, **17R**, and to output to the ECU **100** a detection signal indicative of the detected hydraulic pressure fed to the hydraulic brake units. In this case, a predetermined threshold value is set for the hydraulic pressure of a brake cylinder, and the FB sensor **143** may output a foot brake pedal on-off signal based on whether or not the hydraulic pressure of the brake cylinder is exceeding the previous predetermined threshold value.

The throttle sensor **145** is under the control of the ECU **100**, and adapted to detect the opening degree of a throttle valve of the engine **12** driven by a throttle actuator not shown, and to output a detection signal indicative of the detected opening degree to the ECU **100**. The ECU **100** is adapted to acquire as a throttle opening degree θ_{th} the throttle valve opening degree indicated by the detection signal outputted from the throttle sensor **145**.

The ECU **100** is adapted to acquire the throttle opening degree θ_{th} from the accelerator opening degree Acc based on the throttle opening degree control map so that, without using the detection signal outputted from the throttle sensor **145**, the throttle opening degree θ_{th} obtained from the above throttle opening degree control map can be substituted as a detected value. Here, in the case that the torque reduction control of the

12

engine **12** causes the accelerator opening degree to be changed, the ECU **100** can acquire the throttle opening degree θ_{th} from the changed output reducing accelerator opening degree Accn.

The front wheel rotation speed sensor **161** is under the control of the ECU **100**, and adapted to detect the rotation speed of the front drive shaft **22R** or **22L**, and to output the detection signal indicative of the detected rotation speed to the ECU **100**. Further, the ECU **100** is adapted to acquire as a drive shaft rotation speed Nd the rotation speed of the front drive shaft **22R** or **22L** indicated by the detection signal outputted by the front wheel rotation speed sensor **161**.

The ECU **100** is adapted to calculate a vehicle speed V based on a drive shaft rotation speed Nd acquired from the front wheel rotation speed sensor **161**. Here, the above vehicle speed V is indicative of a vehicle speed of a vehicle travelling on a usual road. The vehicle speed can be replaced by a vehicle speed Vr used for a vehicle travelling on roads possibly causing the front wheel **17L** or **17R** to slip, viz, for example travelling on a bad road and other abnormal situations. The vehicle speed Vr will become apparent as the description proceeds. The front wheel rotation speed sensor **161** is therefore adapted to detect the vehicle speed of the vehicle **10**. This means that the front wheel rotation speed sensor **161** constitutes a vehicle speed detection unit as defined in the present invention.

The rear wheel rotation speed sensor **162** is under the control of the ECU **100**, and adapted to detect the rotation speed of the rear drive shaft **23L** or **23R**, and to output the detection signal indicative of the detected rotation speed to the ECU **100**. Further, the ECU **100** is adapted to acquire as a rear wheel rotation speed Nr the rotation speed of the rear drive shaft **23L** or **23R** indicated by the detection signal outputted by the rear wheel rotation speed sensor **162**.

The ECU **100** is adapted to calculate the vehicle body speed Vr based on the rear wheel rotation speed Nr obtained from the rear wheel rotation speed sensor **162** in the case that only the front wheels **17L**, **17R** are driven, viz., the front wheel drive mode is selected. Here, the rear wheels **18L**, **18R** are each constituted by a rolling wheel not driven by the engine **12**, so that the detection of the rotation speeds of the rear wheels **18L**, **18R** render it possible to obtain the vehicle body speed Vr, i.e., an actual vehicle speed of the vehicle **10**.

As has been described in the above, the rear wheel rotation speed sensor **162** is adapted to detect the rotation speeds of the rear wheels **18L**, **18R**, viz., the vehicle speed of the vehicle **10** from the rotation speeds of the rolling wheels in the two-wheel drive mode. This means that the rear wheel rotation speed sensor **162** constitutes a vehicle body speed detection unit as defined in the present invention.

The transfer input rotation speed sensor **163** is under the control of the ECU **100**, and adapted to detect a rotation speed TRin of the input shaft of the transfer **16** and to output a detection signal indicative of the detected rotation speed to the ECU **100**. More specifically, the ECU **100** is adapted to detect the rotation speed of an input shaft **54** of a transfer clutch **53** as will become more apparent hereinafter.

The transfer output rotation speed sensor **164** is under the control of the ECU **100**, and adapted to detect a rotation speed TRout of an output shaft of the transfer **16**, and to output a detection signal indicative of the detected rotation speed to the ECU **100**. More specifically, the ECU **100** is adapted to detect the rotation speed of the propeller shaft **21**.

The distribution SW sensor **165** is under the control of the ECU **100**, and adapted to detect whether a power changing switch **215** assumes a two-wheel drive selection position or a four-wheel drive selection position, and to output a detection

13

signal indicative of the changed position of the power changing switch **215** to the ECU **100**. The power changing switch **215** may be constructed to be able to select a distribution ratio of the driving forces of the front wheels **17L**, **17R** and the rear wheels **18L**, **18R** in lieu of the alternative selection of the two-wheel drive selection position or the four-wheel drive selection position according to the present invention.

The tilt sensor **166** is under the control of the ECU **100**, and adapted to detect the tilt angle of the vehicle **10** and to output the detection signal indicative of the detected tilt angle to the ECU **100**. More specifically, the tilt sensor **166** has a weight supported by the vehicle **10** to be swingable in the forward, rearward, leftward, and rightward directions, so that the tilt sensor **166** can output to the ECU **100** a detection signal indicative of the movement displacement of the weight swung in response to the inclination of the vehicle **10** in the forward, rearward, leftward, or rightward directions.

The seat position sensor **167** is under the control of the ECU **100**, and adapted to detect the position of the driver's seat to be seated by the driver, and to output a detection signal indicative of the detected position of the driver's seat to the ECU **100**. Here, the present embodiment will be explained with the driver's seat having a smaller value toward the forward position in the vehicle **10**. Here, the forward position is intended to indicate a position closer to the accelerator pedal **212**, the foot brake pedal **213**, and a steering wheel.

In addition, the ECU **100** is adapted to determine whether or not the vehicle **10** is travelling on a bad road based on the position of the driver's seat detected by the seat position sensor **167**. More specifically, the ECU **100** is operative to determine that the vehicle **10** is travelling on a bad road when the value of the position of the driver's seat detected by the seat position sensor **167** is equal to or less than a predetermined value of a bad road determination seat position, viz., a forwardly moved seat position, while the ECU **100** is operative to determine that the vehicle **10** is not travelling on a bad road when the value of the position of the driver's seat detected by the seat position sensor **167** is over the predetermined value of the bad road determination seat position.

Next, the construction of the automatic transmission **13** in the present embodiment will be described with reference to the schematic block diagram shown in FIG. 3.

As shown in FIG. 3, the automatic transmission **13** comprises a torque converter **60** that transmits the torque outputted by the engine **12**, and a transmission mechanism **70** that conducts the speed changes between the rotation speed of the input shaft **71** serving as an input shaft and the rotation speed of the output gear **72** serving as an output gear.

Between the transmission mechanism **70** and the front differential mechanism **14** is generally provided a reduction gear mechanism having the torque inputted by the transmission mechanism **70** to output the torque to the front differential mechanism **14** while reducing the rotation speed and increasing the driving force. For simplifying the explanation hereinafter, the vehicle **10** in the present embodiment will be described as being designed to directly transmit the torque to the front differential mechanism **14** from the transmission mechanism **70** without providing such a reduction gear mechanism.

The torque converter **60** is arranged between the engine **12** and the transmission mechanism **70**, and comprises a pump impeller **63** inputted with the torque from the engine **12**, a turbine runner **64** outputting the torque to the transmission mechanism **70**, a stator **66** that changes the flow direction of oil, and a lock-up clutch **67** that directly connects the pump impeller **63** with the turbine runner **64**, so that the torque can be transmitted through the oil.

14

The pump impeller **63** is connected to the crank shaft **24** of the engine **12**. The pump impeller **63** is designed to be rotated integrally with the crank shaft **24** by the torque of the engine **12**.

The turbine runner **64** is connected to the turbine shaft **62** which is in turn connected to the transmission mechanism **70**. The turbine shaft **62** is directly connected to the input shaft **71** of the transmission mechanism **70**. The turbine runner **64** is rotated by the flow of the oil pushed by the rotation of the pump impeller **63**, and designed to output to the transmission mechanism **70** the rotation of the crank shaft **24** of the engine **12** through the turbine shaft **62**.

The stator **66** is rotatably supported through a one-way clutch **65** by a housing **31** of the automatic transmission **13** constituting a non-rotating member. The stator **66** serves to change the directions in flow of the oil from the turbine runner **64** and into the pump impeller **63** to generate a force to turn the pump impeller **63**. The stator **66** is prevented from rotating by the one-way clutch **65** to change the direction of the oil flowing in the stator **66**.

The stator **66** idles away to prevent a reverse torque from being applied to the turbine runner **64** when the pump impeller **63** and the turbine runner **64** come to be rotated at almost the same rotation speed.

The lock-up clutch **67** is constructed to directly connect the pump impeller **63** and the turbine runner **64** to have the rotation of the crank shaft **24** of the engine **12** mechanically transmitted directly to the turbine shaft **62**.

Here, the torque converter **60** is adapted to transmit the torque through the oil between the pump impeller **63** and the turbine runner **64**. Therefore, the rotation of the pump impeller **63** cannot transmit the torque by 100% to the turbine runner **64**. For this reason, when the speeds of the turbine shaft **62** and the crank shaft **24** become close to each other, the lock-up clutch **67** is operated to mechanically connect the pump impeller **63** and the turbine runner **64** directly, more particularly, to mechanically directly connect the crank shaft **24** to the turbine shaft **62** for more efficient transmission to the transmission mechanism **70** from the engine **12**, thereby resulting in improving the fuel efficiency.

The lock-up clutch **67** is constructed to be able to realize a flex lock-up causing a slip at a predetermined slip ratio. The state of the lock-up clutch **67** is adapted to be selected by the CPU of the ECU **100** in response to the travel state of the vehicle **10**, more specifically, the vehicle speed **V** and the accelerator opening degree **Acc** based on the lock-up control map stored in the ROM of the ECU **100**. In addition, the state of the lock-up clutch **67** can, as described above, assume either one of a converter state having the lock-up clutch **67** released, a lock-up state having the lock-up clutch **67** coupled, and a flex lock-up state having the lock-up clutch **67** slipped.

In addition, the pump impeller **63** is provided with a mechanical type of oil pump **68** that generates hydraulic pressure used for performing the transmission action of the transmission mechanism **70**, and for supplying the oil to activate, lubricate and cool parts and elements.

The transmission mechanism **70** comprises, in addition to the input shaft **71** and the output gear **72**, a first planetary gear **73**, a second planetary gear **74**, a C1 clutch **75**, a C2 clutch **76**, a B1 brake **77**, a B2 brake **78**, a B3 brake **79**, and an F one-way clutch **80**.

The input shaft **71** is directly connected to the turbine shaft **62** of the torque converter **60** so that the input shaft **71** can be directly inputted with the outputted rotation of the torque converter **60**. The output gear **72** is connected with a carrier of the second planetary gear **74** and is held in engagement with

15

a differential ring gear **42** of the front differential mechanism **14** as will be described hereinafter, so that the output gear **72** can function as a counter drive gear. This means that the output gear **72** is adapted to transmit the outputted rotation of the transmission mechanism **70** to the front differential mechanism **14**.

The first planetary gear **73** is constituted by a single pinion type of planetary gear mechanism. The first planetary gear **73** comprises a sun gear **S1**, a ring gear **R1**, a pinion gear **P1**, and a carrier **CA1**.

The sun gear **S1** is coupled to the input shaft **71**. The sun gear **S1** is connected to the turbine shaft **62** of the torque converter **60** through the input shaft **71**. The ring gear **R1** is selectively fixed to the housing **31** of the automatic transmission **13** through the **B3** brake **79**.

The pinion gear **P1** is rotatably supported by the carrier **CA1**. The pinion gear **P1** is held in mesh with the sun gear **S1** and the ring gear **R1**. The carrier **CA1** is selectively fixed to the housing **31** of the automatic transmission **13** through the **B1** brake **77**.

The second planetary gear **74** is constituted by a Ravigneaux type of planetary gear mechanism. The second planetary gear **74** comprises a sun gear **S2**, ring gears **R2**, **R3**, a short pinion gear **P2**, a long pinion gear **P3**, a sun gear **S3**, a carrier **CA2**, and a carrier **CA3**.

The sun gear **S2** is connected with the carrier **CA1** of the first planetary gear **73**. The ring gears **R2**, **R3** are selectively connected to the input shaft **71** through the **C2** clutch **76**. The ring gears **R2**, **R3** are selectively fixed to the housing **31** through the **B2** brake **78**. The ring gears **R2**, **R3** are blocked in rotation in a rotation direction opposite to the rotation direction of the input shaft **71** (hereinafter simply referred to as "opposite direction") by the **F** one-way clutch **80** provided in parallel with the **B2** brake **78**.

The short pinion gear **P2** is rotatably supported by the carrier **CA2**. The short pinion gear **P2** is held in mesh with the sun gear **S2** and the long pinion gear **P3**. The long pinion gear **P3** is rotatably supported by the carrier **CA3**. The long pinion gear **P3** is held in mesh with the short pinion gear **P2**, the sun gear **S3**, and the ring gears **R2**, **R3**.

The sun gear **S3** is selectively connected with the input shaft **71** through the **C1** clutch **75**. The carrier **CA2** is connected with the output gear **72**. The carrier **CA3** is connected to the carrier **CA2** and the output gear **72**.

In addition, the **B1** brake **77**, the **B2** brake **78**, and the **B3** brake **79** are fixed to the housing **31** of the automatic transmission housing **13**. The **C1** clutch **75**, the **C2** clutch **76**, the **F** one-way clutch **80**, the **B1** brake **77**, the **B2** brake **78**, and the **B3** brake **79** (hereinafter simply referred to as "clutch **C**" and "brake **B**", respectively, as long as the above clutches and the above brakes are particularly not needed to be distinguished) are each constituted by a hydraulic type of friction engagement device having a multi-plate type of clutch or brake hydraulically activated and controlled by a hydraulic actuator. The clutch **C** and the brake **B** are changeable to assume the engagement state from the disengagement state, and vice versa, through the hydraulic circuit to be changed by the energization or de-energization of the linear solenoid valves **SL1** to **SL5**, **SLU**, **SLT**, and the on-off solenoid valve **SL** of the hydraulic control device **110** and to be changed by the operation state of the manual valve not shown.

Next, the transmission mechanism **70** of the automatic transmission **13** in the present embodiment will be explained hereinafter with reference to the operating table shown in FIG. **4** while focusing on the engagement state of the frictional engagement elements to realize each of the transmission stages.

16

As shown in FIG. **4**, the operating table to be used for realizing each of the transmission stages shows the engagement and disengagement states to be assumed by each of the frictional engagement elements of the transmission mechanism **70**, viz., the clutches **C** and the brakes **B** to realize each of the transmission stages. In FIG. **4**, the mark "○" (circle) is representative of the engagement, and the mark "X" (cross) is representative of the disengagement. The mark "⊙" (double circle) is representative of the engagement only at the time of applying an engine brake, and the mark "Δ" (triangle) is representative of the engagement only at the time of driving the vehicle **10**.

In accordance with the combination of the engagement and disengagement shown in the operating table, each of the frictional engagement elements are operated by the energization and de-energization or the electric current control of the linear solenoid valves **SL1** to **SL5** provided in the hydraulic control device **110** (see FIG. **1**) and the transmission solenoids not shown to establish the first to sixth stages of the forward speed change stages and the rearward speed change stage.

In accordance with the operating table, the ECU **100** is operated to engage the **F** one-way clutch **80** in addition to the engagement of the **C1** clutch **75** at the time of driving the vehicle **10**, for example, in the case of realizing the first speed state. Further, the ECU **100** is operated to engage the **B2** brake **79** in addition to the **C1** clutch **75** at the time of applying the engine brake in the case of realizing the first speed state.

For realizing the rearward speed change stage, the ECU **100** is operated to engage the **B2** brake **78** and the **B3** brake **79**. Further, for realizing the neutral range and the parking range, the ECU **100** is operated to disengage all of the **C1** clutch **75**, the **C2** clutch **76**, the **B1** brake **77**, the **B2** brake **78**, the **B3** brake **79**, and the **F** one-way clutch **80**. In this way, all of the disengagements of the frictional engagement elements of the transmission mechanism **70** cause the neutral state with no torque transmission between the input side and the output side to be established.

Next, the function about each of the solenoid valves of the hydraulic control device **110** will be explained hereinafter.

The linear solenoid valve **SLT** is adapted to perform the hydraulic control of the line pressure **PL** serving as an original hydraulic pressure of the oil to be supplied to the parts and the elements. More specifically, the linear solenoid valve **SLT** is controlled by the ECU **100** to adjust the line pressure **PL** on the basis of the throttle opening degree θ_{th} , an intake air amount Q_{ar} of the engine **12**, a temperature T_w of the cooling water of the engine **12**, the rotation speed N_e of the engine **12**, the rotation speed N_m of the input shaft, viz., the rotation speed N_t of the turbine, a temperature T_f of the oil in the automatic transmission **13** and the hydraulic control device **110**, shift positions **Psh**, shift ranges, and other factors.

The linear solenoid valve **SLU** is adapted to perform the lock-up control of the lock-up mechanism. More specifically, the linear solenoid valve **SLU** is controlled by the ECU **100** on the basis of the engine speed N_e indicative of the input rotation speed of the torque converter **60**, the turbine rotation speed N_t indicative of the output rotation speed of the torque converter **60**, the throttle opening degree θ_{th} , the vehicle speed V , the input torque, and other factors to adjust the pressure of a lock-up relay valve and a lock-up control valve not shown in the drawings to control the lock-up clutch **67**. The on-off solenoid valve **SL** is adapted to perform the changing operation of the hydraulic pressure of the lock-up relay valve.

The linear solenoid valves **SL1** to **SL5** serve to perform the speed change control. The linear solenoid valves **SL1** and

SL2 function to hydraulically control the C1 clutch 75 and the C2 clutch 76. The linear solenoid valves SL3, SL4 and SL5 are designed to hydraulically control the B1 brake 77, the B2 brake 78, and the B3 brake 79.

The constructions of the front differential mechanism 14 and the transfer 16 in the present embodiment will be explained hereinafter with reference to the schematic block diagram shown in FIG. 5.

As shown in FIG. 5, the front differential mechanism 14 comprises a hollow differential gear case 41, a differential ring gear 42 provided on the outer peripheral portion of the differential gear case 41, a pinion shaft 43 provided in the differential gear case 41, differential pinion gears 44a, 44b, and side gears 45L, 45R. Further, the differential pinion gears 44a, 44b, and the side gears 45L, 45R are each constituted by a bevel gear.

The differential gear case 41 is rotatably supported on and around the front drive shafts 22L, 22R. The differential ring gear 42 is provided on the outer peripheral portion of the differential gear case 41, and in engagement with the output gear 72 of the automatic transmission 13. The pinion shaft 43 is in parallel with the differential ring gear 42 and secured to the differential gear case 41, so that the pinion shaft 43 is rotated integrally with the differential gear case 41.

The differential pinion gears 44a, 44b are rotatably supported on and around the pinion shaft 43. The side gear 45L is securely mounted on and rotated integrally with the front drive shaft 22L, and is held in meshing engagement with the differential pinion gear 44a and the differential pinion gear 44b. In a similar manner, the side gear 45R is securely mounted on and rotated integrally with the front drive shaft 22R, and is held in meshing engagement with the differential pinion gear 44a and the differential pinion gear 44b.

It is thus to be noted that the front differential mechanism 14 is constructed to have the side gear 45L and the side gear 44R rotated together when the differential pinion gear 44a and the differential pinion gear 44b are not rotated. On the other hand, the front differential mechanism 14 is constructed to have the side gear 45L and the side gear 44R relatively rotated in their opposite directions when the differential pinion gears 44a, 44b are rotated. It is therefore understood that the front differential mechanism 14 is constructed to allow the rotation speed difference between the side gear 45L integrally rotated with the front drive shaft 22L and the side gear 45R integrally rotated with the front drive shaft 22R, thereby making it possible to absorb the rotation speed difference between the front wheel 17L and the front wheel 17R when the vehicle is travelling on a curved road.

The rear differential mechanism 15 is the same in construction as the front differential mechanism 14, and thus will not be explained in detail hereinafter. The rear differential mechanism 15 has the differential ring gear 42 held in mesh with the pinion gear of the propeller shaft 21 in place of the output gear 72 of the automatic transmission 13. The rear differential mechanism 15 has the left and right side gears rotated integrally with the rear drive shafts 23L, 23R in lieu of the front drive shafts 22L, 22R.

The transfer 16 comprises a hypoid gear 51, a hypoid pinion 52, and a transfer clutch 53.

The hypoid gear 51 is integrally rotated with the differential gear case 41 of the front differential mechanism 14 to input the torque to the transfer 16 from the automatic transmission 13 through the front differential mechanism 14. The hypoid pinion 52 and the hypoid gear 51 are each constituted by a gear such as for example a bevel gear to change the rotation direction of the torque at an angle of 90 degrees when transmitting the torque inputted from the hypoid gear 51.

The transfer clutch 53 comprises an input shaft 54, a plurality of multi-plate clutch discs 55, a plurality of multi-plate clutch plates 56, and a piston 57, and has a hydraulic servo chamber 58 formed therein. The transfer clutch 53 is constructed to have the hypoid pinion 52 and the propeller shaft 21 connected with each other to make it possible for the torque to be transmitted. The transfer clutch 53 itself is constructed by a known wet multi-plate clutch of a hydraulic servo type.

The input shaft 54 is drivably connected with the hypoid pinion 52 to be inputted with the torque from the hypoid pinion 52 and to output the torque to the multi-plate clutch discs 55. The multi-plate clutch plates 56 are constructed to transmit the torque to the propeller shaft 21. The multi-clutch discs 55 and the multi-plate clutch plates 56 collectively constitute a multi-plate clutch as defined in the present invention.

The hydraulic pressure in the hydraulic servo chamber 58 is controlled by the hydraulic control device, so that the hydraulic pressure fed into the hydraulic servo chamber 58 causes the multi-plate clutch discs 55 and the multi-plate clutch plates 56 to be pressed by the piston 57 at a predetermined pressure, thereby securing a predetermined amount of torque transmission therebetween.

The transfer 16 is constructed to distribute the driving force of the engine 12 to the front wheels 17L, 17R and the rear wheels 18L, 18R as understood from the previous description. This means that the transfer 16 constitutes a driving force distribution device as defined in the present invention.

The following description will be directed to the determination method of a bad road travelling of the vehicle 10 by the ECU 100 according to the present embodiment.

For example, the ECU 100 is adapted to determine whether or not the vehicle 10 is currently travelling on a bad road in accordance with the torque distribution of the transfer 16. More specifically, the ECU 100 is adapted to determine whether or not the vehicle 10 is currently travelling on a bad road in accordance with an input and output rotation speed ratio of the rotation speed TRin of the input shaft of the transfer 16 detected by the transfer input rotation speed sensor 163 and the rotation speed TRout of the output shaft of the transfer 16 detected by the transfer output rotation speed sensor 164 or the changed state of the power changing switch 215 of the transfer 16 detected by the distribution SW sensor 165.

In addition, the ECU 100 is adapted to determine whether or not the vehicle 10 is travelling on a bad road in accordance with the travel mode selected by the driver. Further, the ECU 100 may be adapted to determine whether or not the vehicle 10 is travelling on a bad road in accordance with the tilt angle of the vehicle 10 detected by the tilt sensor 166, the temporal variation in the tilt angle of the vehicle 10, i.e., the rocking motion detected by the tilt sensor 166, the position of the driver's seat detected by the seat position sensor 167, or a difference of the driver's seat position from the position of the driver's seat stored in advance in the EEPROM. Further, the ECU 100 can determine whether or not the vehicle 10 is travelling on a bad road in accordance with the topographical information of the current position acquired by the navigation system 170.

The ECU 100 is designed to use one of or a combination of the bad road travelling determination methods previously described for determining whether or not the vehicle 10 is travelling on a bad road.

The characteristic construction of the ECU 100 mounted on the vehicle 10 in the embodiment according to the present invention will be explained hereinafter.

The ECU 100 is adapted to determine that the control permission is established when the depression of the accelerator pedal 212 is detected by the accelerator sensor 142, and the depression of the foot brake pedal 213 is detected by the FB sensor 143. Further, the ECU 100 is adapted to determine that the control permission condition is not established and not to execute a reduction control to reduce the driving force outputted from the engine 12 when the ECU 100 determines not to judge whether or not the accelerator pedal 212 and the foot brake pedal 213 are operated intentionally by a driver.

The ECU 100 is adapted to determine that the control permission condition is not established for the predetermined period and not to execute the reduction control when the ECU 100 determines not to judge whether or not the accelerator pedal 212 and the foot brake pedal 213 are operated intentionally by a driver. Further, The ECU 100 is adapted to determine that the control permission condition is not established until the end of the current trip and not to execute the reduction control when the ECU 100 determines not to judge whether or not the accelerator pedal 212 and the foot brake pedal 213 are operated intentionally by a driver. Here, the trip means, for example, the time period from the time a starting switch of a vehicle 10 such as an ignition switch is turned on until the time the starting switch is turned off.

The ECU 100 is further adapted to determine that the control permission condition is established when the depression of the foot brake pedal 213 is detected by the FB sensor 143 in the state that the depression of the accelerator pedal 212 is being detected by the accelerator sensor 142. The ECU 100 is further adapted to determine that the control permission condition is established when the deceleration of the vehicle 10 is determined. This means that the ECU 100 constitutes a permission condition determination unit as defined in the present invention.

Further, the ECU 100 is adapted to execute a reduction control to reduce the driving force outputted from the engine 12 when the ECU 100 determines that the control permission condition is established. The ECU 100 is further adapted to execute the reduction control when the vehicle speed V detected by the front wheel rotation speed sensor 161 is equal to or faster than a predetermined vehicle speed. Moreover, the ECU 100 is adapted to execute the reduction control when the control permission condition is established for a predetermined period of time or longer.

The ECU 100 is further adapted to finish the reduction control when the amount of depression of the accelerator pedal 212 detected by the accelerator sensor 142 is changed by a predetermined amount of depression or larger. The ECU 100 is adapted to finish the reduction control of the driving force outputted from the engine 12 when the foot brake pedal 213 not being depressed is detected by the FB sensor 143. This means that the ECU 100 constitutes an output control unit as defined in the present invention.

Further, the ECU 100 is adapted to determine whether or not to judge that the accelerator pedal 212 and the foot brake pedal 213 are operated intentionally by a driver, based on the detection results by the accelerator sensor 142 and the FB sensor 142.

More specifically, the ECU 100 is adapted to determine not to judge whether or not the accelerator pedal 212 and the foot brake pedal 213 are operated intentionally by a driver, when the state the depression of the accelerator pedal 212 is detected by the accelerator sensor 142 and the depression of the foot brake pedal 213 is detected by the FB sensor 143 continues for the predetermined period, e.g., no less than 10 seconds. In addition, the ECU 100 is adapted to determine not to judge whether or not the accelerator pedal 212 and the foot

brake pedal 213 are operated intentionally by a driver, when the state the depression of the accelerator pedal 212 is detected by the accelerator sensor 142 and the depression of the foot brake pedal 213 is detected by the FB sensor 143 occurs at the predetermined frequency, e.g., 10 or more times per minute. This means that the ECU 100 constitutes the intention judgment determination unit as defined in the present invention.

The ECU 100 is further adapted to determine the deceleration based on the state of the vehicle 10. The ECU 100 is adapted to determine the deceleration based on the amount of depression of the foot brake pedal 213 detected by the FB sensor 143. The ECU 100 is further adapted to determine the deceleration based on the rotation speed of the rear wheels 18L, 18R constituted by the rolling wheels detected by the rear wheel rotation speed sensor 162. This means that the ECU 100 constitutes a deceleration determination unit as defined in the present invention.

Next, the operation of the vehicle control process in the present embodiment will be explained with reference to the flowchart shown in FIG. 6.

The flow chart shown in FIG. 6 shows the execution content of the program of the vehicle control process to be executed by the ECU 100 with the RAM as a work area. The program of the vehicle control process is stored in the ROM of the ECU 100. The vehicle control process is adapted to be executed by the CPU of the ECU 100 at a time interval set in advance.

As shown in FIG. 6, the ECU 100 is initially operated to determine whether or not the flag of the output reduction prohibition is on (Step S21). Here, the flag of the output reduction prohibition is indicative of a determination flag that determines the prohibition of executing the reduction control of the engine 12, and the execution is prohibited when the flag of the output reduction prohibition is "on" and the execution is allowed when the flag of the output reduction prohibition is "off".

When the ECU 100 determines that the flag of the output reduction prohibition is "on" ("YES" in Step S21), the ECU 100 then determines whether or not the predetermined time has elapsed since the flag of the output reduction prohibition is turned "on", and finishes the vehicle control process if the predetermined time has not elapsed (Step S22).

Determination of the end of the current trip can be used in lieu of the determination by the elapsed time since the flag of the output reduction prohibition is turned "on". This results in the fact that the flag of the output reduction prohibition is "on" and the control permission condition is not established until the end of the current trip, and the reduction control of the engine 12 can be not executed until the restart of the engine 12. In this case, the flag of the output reduction prohibition is turned "off" at the start of the engine 12. Moreover, the establishment of either or both of the determination of the elapsed time and the determination of the end of the current trip can be used for the determination in the vehicle control process in the present embodiment.

When the ECU 100 determines that the predetermined time has elapsed since the flag of the output reduction prohibition is turned "on" ("YES" in Step S22), the ECU 100 turns "off" the flag of the output reduction prohibition (Step S23).

Next, when the ECU 100 determines that the predetermined time has elapsed since the flag of the output reduction prohibition is turned "on" ("YES" in Step S22), if the flag of the output reduction prohibition is turned "off" (Step S23) or the ECU 100 determines that the flag of the output reduction prohibition is "off" ("NO" in Step S21), the ECU 100 determines whether or not the vehicle is travelling on a bad road

21

(Step S11). One or more determination methods in combination on whether or not the vehicle is travelling on a bad road are carried out by the ECU 100.

The ECU 100 is adapted to finish the vehicle control process when the vehicle is determined by the ECU 100 to be travelling on a bad road ("YES" in Step S11), resulting from the fact that the reduced output of the engine 12 tends to cause hesitation and others, thereby deteriorating the drivability.

When, on the other hand, the vehicle is determined by the ECU 100 to be not travelling on a bad road ("NO" in Step S11), the ECU 100 then determines whether or not the accelerator is "on" and finishes the vehicle control process if the accelerator is not "on" (Step S12). More specifically, the ECU 100 is adapted to determine whether or not the accelerator opening degree Acc detected by the accelerator sensor 142 is equal to or more than the accelerator pedal depression determination value Acc_tv stored in the ROM. When the ECU 100 determines that the accelerator opening degree Acc is equal to or more than the accelerator pedal depression determination value Acc_tv, the ECU 100 determines that the accelerator pedal 212 is depressed, viz., the accelerator is "on". When, on the other hand, the ECU 100 determines that the accelerator opening degree Acc is less than the accelerator pedal depression determination value Acc_tv, the ECU 100 determines that the accelerator pedal 212 is not depressed, viz., the accelerator is "off".

When the ECU 100 determines that the accelerator is "on" ("YES" in Step S12), the ECU 100 then determines whether or not the brake is "on" and finishes the vehicle control process if the brake is not "on" (Step S13). More specifically, the ECU 100 determines whether or not the brake pedal depression force Bf detected by the FB sensor 143 is equal to or more than the brake pedal depression determination value Bf_tv stored in the ROM. When the ECU 100 determines that the brake pedal depression force Bf detected by the FB sensor 143 is equal to or more than the brake pedal depression determination value Bf_tv, the ECU 100 determines that the foot brake pedal 213 is depressed, viz., the brake is "on". When, on the other hand, the ECU 100 determines that the brake pedal depression force Bf is less than the brake pedal depression determination value Bf_tv, the ECU 100 determines that the foot brake pedal 213 is not depressed, viz., the brake is "off".

The ECU 100 is adapted to transfer the current brake information stored in the RAM to the previous brake information at the time of the brake-on determination process (Step S13), and stores the determined brake information to the RAM as the current brake information. Here, the brake information is information indicative of the state of the brake, viz., brake-on or brake-off. When the accelerator is "on" ("YES" in Step S12) and the brake is "on" ("YES" in Step S13), the ECU 100 starts a timer and monitors the duration of the accelerator and the brake being depressed together.

When the ECU 100 determines that the brake is "on" ("YES" in Step S13), the ECU 100 then determines whether or not the previous brake state is "off" and finishes the vehicle control process (Step S14) if the previous brake state is not "off". More specifically, the ECU 100 reads the previous brake information stored in the RAM, and determines whether or not the brake state is "off".

By the accelerator-on determination process (Step S12), the brake-on determination process (Step S13), and the previous brake-off determination process (Step S14), it can be determined by the ECU 100 that the foot brake pedal 213 is depressed later in the state that the accelerator pedal 212 is being depressed.

22

When the ECU 100 determines that the previous brake state is "off" ("YES" in Step S14), the ECU 100 then performs speed reduction determination, and finishes the vehicle control process (Step S15) if the vehicle 10 is not in speed reduction. More specifically, the ECU 100 determines whether or not the vehicle speed V calculated from the rotation speed detected by the front wheel rotation speed sensor 161 is lowered by a predetermined vehicle speed or larger. If the vehicle speed V is lowered by the predetermined vehicle speed or larger, it is determined by the ECU 100 that the vehicle is decelerated, and if the vehicle speed V is lowered not by the predetermined vehicle speed or larger, it is determined by the ECU 100 that the vehicle is not decelerated. While the predetermined vehicle speed for the ECU 100 to determine the deceleration may be a fixed value, it is desirable that the value corresponds to the vehicle speed V.

Furthermore, the above deceleration determination does not result in any problem because the process is essentially performed while the vehicle is driving on a normal road, but not on a bad road. However, to cope with bad road driving, it is conceivable that the process is performed as follows.

For example, the ECU 100 determines whether or not the brake pedal force Bf detected by the FB sensor 143 is not less than the deceleration brake determination value BfDc_tv stored in the ROM. If the brake pedal force Bf is not less than the deceleration brake determination value BfDc_tv, the ECU 100 determines that the vehicle is decelerated, and if the brake pedal force Bf is below the deceleration brake determination value BfDc_tv, the ECU 100 determines that the vehicle is not decelerated.

At the time when the two-wheel drive mode is selected in the transfer 16, the ECU 100 can determine the deceleration by the amount of change in the vehicle body speed Vr. The vehicle body speed Vr can be obtained from the rotation speed detected by the rear wheel rotation speed sensor 162 which are capable of detecting the rotation speed of the rear wheels 18L, 18R, i.e., the rolling wheels. While the vehicle is a two-wheel drive vehicle type, and thus is provided with no transfer 16, the vehicle is to travel in the two-wheel driven mode at all times with either pair of the rear wheels 18L, 18R or the front wheels 17L, 17R serving as the rolling wheels. Accordingly, the above deceleration determination can be performed if the vehicle body speed Vr is always obtained by the rear wheel rotation speed sensor 162 or the front wheel rotation speed sensor 161.

Moreover, the vehicle 10 may be provided with an acceleration sensor for detecting the acceleration of the vehicle 10 to have the ECU 100 perform the deceleration determination in accordance with the acceleration detected by the acceleration sensor.

When the ECU 100 determines the speed reduction ("YES" in Step S15), the ECU 100 determines whether or not the state of the accelerator pedal and the brake pedal being depressed together continues for less than 10 seconds (Step S16). In the determination of both pedals depressed (Step S16), when both the accelerator pedal 212 and the foot brake pedal 213 are depressed for 10 or more seconds, the driver may tend to depress the accelerator pedal 212 and the foot brake pedal 213 separately with both feet and may be just putting a foot on the foot brake pedal 213. In this case, as the driver may not have intention to operate the brake pedal and the intention judgment determination unit determines not to judge whether or not the brake pedal are depressed intentionally by the driver, the ECU 100 is adapted to determine not to execute the reduction control of the engine 12.

In addition, the ECU 100 can determine whether or not both the accelerator pedal 212 and the foot brake pedal 213

are depressed at the predetermined frequency, e.g., 10 or more times per minute in lieu of the determination of the time period for the state of the accelerator pedal and the brake pedal being depressed together (Step S16). When both the accelerator pedal **212** and the foot brake pedal **213** are depressed at the predetermined frequency, e.g., 10 or more times per minute, the driver may tend to depress the accelerator pedal **212** and the foot brake pedal **213** separately with both feet and may be just putting a foot on the foot brake pedal **213**. In this case, as the driver may not have intention to operate the brake pedal and the intention judgment determination unit determines not to judge whether or not the brake pedal are depressed intentionally by the driver, the ECU **100** is adapted to determine not to execute the reduction control of the engine **12**. Moreover, the establishment of either or both of the determination of the time period for "both depressed" and the determination of the frequency for "both depressed" can be used for the determination in the vehicle control process in the present embodiment.

When the ECU **100** determines the state of the accelerator pedal and the brake pedal being depressed together continues for less than 10 seconds ("NO" in Step S16), the ECU turns the flag of the output reduction prohibition "on" and starts measuring the elapsed time of the output reduction prohibition, and then finishes the vehicle control process (Step S24).

On the other hand, when the ECU **100** determines that the state of the accelerator pedal and the brake pedal being depressed together continues for less than 10 seconds ("YES" in Step S16), the ECU **100** then determines whether or not the control permission condition (Step S11 to Step S16) continues for a predetermined period of time, and the vehicle speed V is equal to or more than 7 (km/h). The ECU **100** finishes the vehicle control process (Step S17) if the control permission condition established is not continuing for the predetermined period of time or if the vehicle speed is less than 7 (km/h) (Step S17). Here, the detection value to be used for the vehicle speed determination is preferably the vehicle body speed V_r as previously mentioned.

When the ECU **100** determines that the control permission condition continues for the predetermined period of time and the vehicle speed is equal to or more than 7 (km/h) ("YES" in Step S17), the ECU **100** performs the reduction control process of the engine output (Step S18). For example, the ECU **100** rewrites the accelerator opening degree to the output reducing accelerator opening degree Acc_n stored in the ROM for reducing the output of the engine **12** from the real accelerator opening degree Acc , thereby reducing the engine output lower than the real accelerator opening degree Acc . Here, the rate of reduction of the engine output, i.e., the rate of conversion from the actual accelerator opening degree Acc to the output reducing accelerator opening degree Acc_n , can be set corresponding to the rate of the vehicle speed, thereby making it possible that the time period for reducing the engine output to the desired engine output can be equal to the certain value.

Then, the ECU **100** determines whether or not the brake is "off" or the state of the hysteresis width of the accelerator opening degree exceeding a predetermined hysteresis width continues for a predetermined period of time. When the ECU **100** determines that the brake is "on" and the hysteresis width of the accelerator opening degree is equal to or less than the predetermined hysteresis width, or a predetermined period of time has not elapsed even if the hysteresis width of the accelerator opening exceeds the predetermined hysteresis width, the ECU **100** returns (Step S19) to the reduction control process (Step S18) of the engine output. Here, the hysteresis width of the accelerator opening degree is intended to indicate

the difference between the actual accelerator opening degree Acc before the reduction control process (Step S18) of the engine output and the current actual accelerator opening degree Acc detected by the accelerator sensor **142**.

When the ECU **100** determines that the brake is "off", or the state of the hysteresis width of the accelerator opening degree exceeding the predetermined hysteresis width continues for a predetermined period of time ("YES" in Step S19), the ECU **100** performs the output returning process of the engine **12** and finishes the vehicle control process (Step S20). For example, when the ECU **100** rewrites the accelerator opening degree in the reduction control process (Step S18) of the engine output, the accelerator opening degree is returned to the actual accelerator opening degree Acc detected by the accelerator sensor **142** to return the output of the engine **12** to the output at the time of usual vehicle travel.

As described above, the vehicle control apparatus according to the present embodiment is operated to execute the reduction control to reduce the torque outputted from the engine **12** when the control permission condition is established, and the vehicle control apparatus is operated not to execute the reduction control when it determines not to judge whether or not the accelerator pedal **212** and the foot brake pedal **213** are depressed intentionally by the driver. As a consequence, when the possibility is high that the foot brake pedal **213** is depressed unintentionally by the driver, the vehicle can be prevented from being reduced the torque outputted from the engine **12**, thereby making it possible to prevent the drivability from being deteriorated.

The vehicle control apparatus according to the present embodiment is operated not to judge whether or not the brake pedal are depressed intentionally by the driver when both the accelerator pedal **212** and the foot brake pedal **213** are depressed for 10 or more seconds, and the driver may tend to depress the accelerator pedal **212** and the foot brake pedal **213** separately with both feet and may be just putting a foot on the foot brake pedal **213**. As a consequence, the vehicle control apparatus can prevent the reduction control from being executed excessively and prevent the driving force from being reduced unnecessarily, thereby making it possible to prevent the drivability from being deteriorated.

The vehicle control apparatus according to the present embodiment is operated not to judge whether or not the brake pedal are depressed intentionally by the driver in the same manner as described above when both the accelerator pedal **212** and the foot brake pedal **213** are depressed 10 or more times per minute, and the driver may tend to depress the accelerator pedal **212** and the foot brake pedal **213** separately with both feet and may be just putting a foot on the foot brake pedal **213**. As a consequence, the vehicle control apparatus can prevent the reduction control from being executed excessively and prevent the driving force from being reduced unnecessarily, thereby making it possible to prevent the drivability from being deteriorated.

Moreover, as the state that the intention judgment determination unit determines not to judge whether or not the brake pedal are depressed intentionally by the driver continues for a while, the vehicle control apparatus according to the present embodiment is operated to determine the control permission condition is not established, and thus the vehicle control apparatus can prevent the driving force from being reduced unnecessarily, thereby making it possible to prevent the drivability from being deteriorated. For example, in the case that the driver depresses the brake pedal significantly by fatigue even if the driver who tends to depress the accelerator pedal and the brake pedal separately with both feet is just putting a foot on the brake pedal, as the state that the depression of both

25

the accelerator pedal and the brake pedal are concurrently detected continues for a while, the vehicle control apparatus determines the control permission condition is not established during the period. In addition, in the case that the vehicle control apparatus determines the accelerator pedal and the brake pedal are depressed intentionally by the driver, there is a high possibility that the accelerator pedal and the brake pedal are depressed again intentionally at the same time. Therefore, the vehicle control apparatus can prevent the driving force from being reduced unnecessarily by determining the control permission condition is not established for the predetermined time period, thereby making it possible to prevent the drivability from being deteriorated.

The vehicle control apparatus according to the present embodiment is operated to determine that the control permission condition is not established until the end of the current trip in the case that the vehicle control apparatus determines not to judge the intention of the driver. There is low possibility that the driver is changed until the end of the current trip in the case that the vehicle control apparatus determines not to judge the intention of the driver because of the driver's operation methods, habits and others. Therefore, the vehicle control apparatus can prevent the driving force from being reduced unnecessarily by determining the control permission condition is not established, thereby making it possible to prevent the drivability from being deteriorated. On the other hand, in the case that the vehicle control apparatus judges that the acceleration pedal **212** and foot brake pedal **213** is depressed intentionally by the driver, even if the acceleration pedal **212** and foot brake pedal **213** are depressed again simultaneously during the current trip, there is high possibility that the operation is executed intentionally by the driver. Therefore, the vehicle control apparatus can prevent the driving force from being reduced unnecessarily by determining the control permission condition is not established until the end of the current trip, thereby making it possible to prevent the drivability from being deteriorated.

While the previously mentioned embodiments have been explained about the vehicle **10** with an engine **12** functioning as a power source using gasoline as a fuel, the present invention is not limited to these embodiments, but the present invention can be applied to an electric vehicle having one or more electrical motors as power sources, a hydrogen automobile having a power source of an engine using hydrogen as a fuel, and a hybrid vehicle using both an engine and an electric motor as drive sources. In these cases, the power source to lower the output is not limited to the engine **12**, but the driving force of the electric motor may be lowered according to the present invention.

While the previously mentioned embodiments each including only one ECU have been explained, the invention is not limited to these embodiments, but the vehicle control apparatus may be constructed with a plurality of ECUs according to the present invention. For example, the ECU **100** forming part of each of the above described embodiments may be constructed by a plurality of ECUs such as an E-ECU that executes the combustion control of the engine **12**, and a T-ECU that executes the transmission control of the automatic transmission **13** according to the present invention. In this case, each of the above ECUs may be operative to be held in communication with other ECUs for mutual input and output of necessary information.

As will be understood from the foregoing description, the vehicle control apparatus according to the present invention has such an advantageous effect that the vehicle control apparatus is operative to allow the driver to drive without reducing the driving force outputted from the power source when the

26

possibility is high that the driver is depressing the brake pedal unintentionally, thereby making it possible to prevent the drivability from being deteriorated. The vehicle control apparatus according to the present invention is therefore useful as a vehicle control apparatus that performs the suppression control of the output of a power source.

REFERENCE SIGNS LIST

- 10** Vehicle
- 12** Engine (power source)
- 13** Automatic transmission
- 14** Front differential mechanism
- 15** Rear differential mechanism
- 16** Transfer
- 17L, 17R** Front wheel
- 18L, 18R** Rear wheel
- 21** Propeller shaft
- 22L, 22R** Front drive shaft
- 23L, 23R** Rear drive shaft
- 41** Differential gear case
- 51** Hypoid gear
- 52** Hypoid pinion
- 53** Transfer clutch
- 54** Input shaft
- 100** ECU (permission condition determination unit, output control unit, intention judgment determination unit, deceleration determination unit)
- 110** Hydraulic control device
- 120** Operation panel
- 131** Crank sensor
- 142** Accelerator sensor (accelerator opening degree detection unit)
- 143** FB sensor (brake detection unit, brake pedal force detection unit)
- 145** Throttle sensor
- 161** Front wheel speed sensor (vehicle speed detection unit)
- 162** Rear wheel speed sensor (vehicle body speed detection unit)
- 163** Transfer input speed sensor
- 164** Transfer output speed sensor
- 165** Distribution SW sensor
- 166** Tilt sensor
- 167** Seat position sensor
- 170** Navigation system
- 212** Accelerator pedal
- 213** Foot brake pedal
- 215** Power changing switch

The invention claimed is:

1. A vehicle control apparatus for a vehicle provided with a power source, an accelerator pedal, and a brake pedal, the vehicle control apparatus comprising:

- an accelerator detection unit configured to detect a depression of the accelerator pedal;
- a brake detection unit configured to detect a depression of the brake pedal;
- a permission condition determination unit for determining that a control permission condition is established when the depression of the accelerator pedal is detected by the accelerator detection unit, and the depression of the brake pedal is detected by the brake detection unit;
- an output control unit configured to execute a reduction control to reduce a driving force outputted by the power source when the control permission condition established is determined by the permission condition determination unit; and

27

an intention judgment determination unit configured to determine whether or not to judge that the accelerator pedal and the brake pedal are operated intentionally by a driver in accordance with the results detected by the accelerator detection unit and the brake detection unit, wherein the intention judgment determination unit is configured to determine not to judge whether or not the accelerator pedal and the brake pedal are operated intentionally by the driver when the state that the depression of the accelerator pedal is detected by the accelerator detection unit, and the state that the depression of the brake pedal is detected by the brake detection unit continues for at least a preset duration of time, the permission condition determination unit is configured to determine that the control permission condition is not established and not to have the output control unit execute the reduction control, when the intention judgment determination unit determines not to judge whether or not the accelerator pedal and the brake pedal are operated intentionally by the driver, and wherein the output control unit is configured to execute the reduction control, if the control permission condition continues for at least a predetermined period of time and vehicle speed is equal to or more than a preset value, but not longer than the preset duration of time.

2. The vehicle control apparatus as set forth in claim 1, in which the intention judgment determination unit is configured to determine not to judge whether or not the accelerator pedal and the brake pedal are operated intentionally by the driver when the state that the depression of the accelerator pedal is detected by the accelerator detection unit, and the state that the depression of the brake pedal is detected by the brake detection unit occurs at a predetermined frequency.

3. The vehicle control apparatus as set forth in claim 1, in which the permission condition determination unit is configured to determine that the control permission condition is not established for a predetermined time period, and to prohibit the output control unit from executing the reduction control when the intention judgment determination unit determines not to judge whether or not the accelerator pedal and the brake pedal are operated intentionally by the driver.

4. The vehicle control apparatus as set forth in claim 1, in which the permission condition determination unit is configured to determine that the control permission condition is not established until the end of a current trip, and to prohibit the output control unit from executing the reduction control when the intention judgment determination unit determines not to judge whether or not the operations of the accelerator pedal and the brake pedal are operated intentionally by the driver.

5. The vehicle control apparatus as set forth in claim 1, in which the permission condition determination unit is configured to determine that the control permission condition is established when the depression of the brake pedal is

28

detected by the brake detection unit in the state that the depression of the accelerator pedal is detected by the accelerator detection unit.

6. The vehicle control apparatus as set forth in claim 1, which further comprises a speed reduction determination unit configured to detect the state of the vehicle to determine a speed reduction of the vehicle, and in which the permission condition determination unit is configured to determine that the control permission condition is established when the speed reduction of the vehicle is determined by the speed reduction determination unit.

7. The vehicle control apparatus as set forth in claim 6, which further comprises a brake depression force detection unit configured to detect a depression amount of the brake pedal, and in which the speed reduction determination unit is configured to determine the speed reduction in accordance with the depression amount of the brake pedal detected by the brake depression force detection unit.

8. The vehicle control apparatus as set forth in claim 6, which further comprises a vehicle body speed detection unit configured to detect a travel speed of the vehicle from the rotation number of driven wheels, and in which the speed reduction determination unit is configured to determine the speed reduction in accordance with the varied rotation number of the driven wheels detected by the vehicle body speed detection unit.

9. The vehicle control apparatus as set forth in claim 1, which further comprises a vehicle speed detection unit configured to detect a vehicle speed, and in which the output control unit is configured to execute the reduction control when the vehicle speed detected by the vehicle speed detection unit is not less than a predetermined vehicle speed.

10. The vehicle control apparatus as set forth in claim 1, in which the output control unit is configured to execute the reduction control when the control permission condition established for no less than a predetermined time is determined by the permission condition determination unit.

11. The vehicle control apparatus as set forth in claim 1, in which the accelerator detection unit is configured to detect an amount of depression of the accelerator pedal, and the output control unit is configured to finish the reduction control when the amount of depression of the accelerator pedal detected by the accelerator detection unit is varied larger than a predetermined depression amount.

12. The vehicle control apparatus as set forth in claim 1, in which the output control unit is configured to finish the reduction control of the driving force outputted from the power source when the brake pedal not depressed is detected by the brake detection unit.

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